WATERSHED WORK PLAN
for
WATERSHED PROTECTION
and
FLOOD PREVENTION

LITTLE WALNUT-HICKORY WATERSHED
BUTLER AND GREENWOOD COUNTIES,
KANSAS

MARCH 1963

WATERSHED WORK PLAN

FOR

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Butler and Greenwood Counties, Kansas

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Prepared Under the Authority of the
Watershed Protection and Flood Prevention Act
(Public Law 566, 83rd Congress; 68 Stat. 666), as amended.

Prepared by

Butler County Soil Conservation District
Greenwood County Soil Conservation District
Little Walnut-Hickory Watershed Joint District

With Assistance by

U. S. Department of Agriculture
Soil Conservation Service
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SUMMARY OF PLAN

This plan for watershed protection and flood prevention is sponsored by the Little Walnut-Hickory Watershed Joint District No. 18 and the Butler and Greenwood County Soil Conservation Districts. Technical assistance in preparing the watershed work plan was provided by the Soil Conservation Service and the Forest Service, United States Department of Agriculture. The Soil Conservation Service negotiated a contract with Wilson and Company, Engineers and Architects, Salina, Kansas, to collect and process engineering data. The State of Kansas, through the State Soil Conservation Committee, provided funds for these services.

Little Walnut-Hickory Watershed covers 268 square miles or 171,510 acres located in the Bluestem Hills of south central Kansas. It is one of six organized watershed districts in the Walnut River Basin. The six watershed districts encompass 1,568 square miles of the 1,955 square miles of the Walnut River drainage area. Four of these watersheds are currently being planned under authority of Public Law 566 and the other two watershed districts have submitted four applications. The location of these watersheds and proposed water resource projects of other agencies are shown on the Walnut Basin map.

Land use of the watershed is approximately 70 percent native grassland, 25 percent cropland, 2 percent woodland, and 3 percent other land.

Floodwater damage to crops, land, other agricultural property, roads and bridges are serious watershed problems. The floodplain contains 13,800 acres. The flood prevention measures will reduce floodwater damages by 53 percent.

The installation period is 5 years.

The total estimated cost is $2,695,700 of which $2,113,500 will be Public Law 566 funds and $582,200 from other sources.

Land Treatment Measures

The cost of the land treatment measures for watershed protection is estimated at $434,700. The share from P.L. 566 funds, consisting entirely of technical assistance is $74,000. The share from other funds is estimated at $360,700. Cost sharing and technical assistance available under other programs will be utilized in applying these measures.

Structural Measures

The structural measures consist of 40 floodwater retarding structures. This system of structures has a total capacity of 19,722 acre feet, of which 17,075 acre feet is for detention storage and 2,647 acre feet is for sediment storage. The system will provide runoff control for a drainage area of 92.23 square miles (59,027 acres) which is 34 percent of the watershed area.

The total cost of all structural measures is $2,261,000 of which $2,039,500 will be borne by P.L. 566 funds and $221,500 by local interests.

Damages and Benefits

Average annual floodwater and land damages of $290,800 without the project will be reduced to $137,700 with the project installed, resulting in average annual damage reduction benefits of $153,100. Benefits of $15,800 from changed land use, $13,000 from more intensive use, and $15,400 from damage reduction off project, brings the total average annual benefits to $197,300, of which $5,200 is attributable to land treatment and $192,100 to structural measures. The ratio of the average annual benefits for structural measures, $192,100, to the average annual cost, $90,000, is 2.1 to 1.

Arrangements for Carrying Out the Project

The Little Walnut-Hickory Watershed Joint District will provide land easements and rights-of-way and will contract for construction of the floodwater retarding structures. The Kansas Watershed District Act provides for the method of financing to be considered concurrently with adoption of the general plan.

Operation and Maintenance

The land treatment measures will be maintained by landowners and operators of the farms on which measures are installed. This will be done under agreement with the Butler and Greenwood County Soil Conservation Districts.

The floodwater retarding structures will be operated and maintained by the Little Walnut-Hickory Watershed Joint District at an average annual cost of $5,500.

DESCRIPTION OF THE WATERSHED

Physical Data

The Little Walnut-Hickory Watershed lies in the Bluestem Hills area of south central Kansas. It contains 171,510 acres of which 169,000 acres are in Butler County and 2,510 acres in Greenwood County. The watershed is approximately 36 miles long and 20 miles wide. The floodplain covers 13,800 acres.

The watershed is comprised of the total area drained by Hickory Creek and the Little Walnut River. Hickory Creek is a tributary of the Little Walnut River which is a tributary of the Walnut River and enters that stream approximately one and one-half miles north of Douglass, Kansas. The Walnut River is a tributary of the Arkansas River.

The terrain is rolling with elevations ranging from 1,600 feet at the top of the watershed to 1,140 at its junction with the Walnut River. U-shaped valleys have developed over resistant flat limestone layers that dip gently in the general direction of the main stream flow.

Cropland dominates the valleys of Little Walnut River and Hickory Creek from the mouth to within a few miles from the head of the streams. The rich alluvial soil lends itself to cultivation. Structures will consequently flood cropland except when located in the extreme upper reaches.

The upland soils are silty clay to clay loams in texture with moderate depths. The valley soils are deep, friable and productive.

Land use of the watershed is divided in approximately the following percentages: 70 grassland, 25 cropland, 2 woodland, and 3 miscellaneous. The principal crops grown are feed grains, alfalfa, and small grains.

The average annual precipitation for Wichita, Kansas, located 20 miles west of the watershed is 30.74 inches. The minimum recorded annual rainfall at Wichita was 12.73 inches in 1956 and the maximum was 50.48 inches in 1951. The precipitation is distributed so that normally about 75 percent falls during the growing season, April to October. The most intense flood producing storms occur during the summer months. The highest temperature recorded is 114 degrees and the lowest 22 degrees below zero. The average date of the last killing frost in spring is April 19 and the first killing frost in the fall is October 20. The average length of the growing season is 184 days.

Economic Data

Little Walnut-Hickory Watershed is predominately a livestock area. Most ranches are well-balanced units, with upland pasture and valley cropland, suitable to a cattle enterprise on a year long basis. In the lower reaches of the watershed, cash crop production with winter feeding of cattle is a major practice.

The floodplain cropland of 9,800 acres represents about 23 percent of the total cropland and about 6 percent of the total watershed.

Land use, under present conditions and with the program installed, is as follows:

Land Use	Present		With Program	
	Watershed Total	Flood plain	Watershed Total	Flood plain
Cropland	42,200	9,800	41,700	10,300
Pasture	121,100	700	122,000	600
Woodland	3,100	3,000	2,700	2,600
Miscellaneous	5,100	300	5,100	300
Total	171,500	13,800	171,500	13,800

The principal crops are alfalfa, corn, milo, wheat, forage sorghums, soybeans, and tame grasses. A composite acre of floodplain is made up of percentages in various uses with average flood-free yields as follows:

Crops	Percent Use	Flood-free Yield
Alfalfa	20	4 Ton
Corn	20	65 Bu.
Milo	20	70 Bu.
Wheat	15	35 Bu.
Timber & Miscellaneous	10	--
Forage Sorghums	5	15 Ton
Soybeans	5	25 Bu.
Tame grasses	5	10 A.U.M.

There are about 650 landowners with about 175 operating units in the watershed. These operating units range in size from 240 acres to 5,000 acres with the average about 1,000 acres. Land values, including buildings, is about 110 dollars per acre. About 40 percent of the farmers own the land they operate, 30 percent own part of their operating units, while 30 percent are tenant operators.

The only incorporated town in the watershed, Leon (population 540), is located on the Little Walnut Branch. Beaumont, an unincorporated town, is located near the upper end of the watershed. El Dorado (population 12,500) nine miles north and Augusta (population 6,400) ten miles west of the watershed, provide adequate trade and market facilities.

A system of roads, as shown on the Project Map, provides access to all parts of the watershed. State Highway 96 traverses the northern one-third of the watershed, crossing the Little Walnut branch at Leon. Federal Highway 77 crosses the mainstem about one and one half miles above its junction with the Walnut River.

The Frisco railroad traverses the watershed. There is minor oil activity within the area. All the farmers have modern farm machinery and their farm homes have electricity, television, telephones, and other modern conveniences.

WATERSHED PROBLEMS

Floodwater Damage

Both the Little Walnut and Hickory branches are subject to frequent and severe flooding. Overbank flooding occurred 12 times in 1951. Over the last 56 years, major flooding has occurred at least once every three years and minor flooding once every fourteen months.

The floodplain of Little Walnut-Hickory covers 13,800 acres, of which 9,800 acres is cropland valued at $200 per acre.

Crop damage amounts to $191,400 on an average annual basis and accounts for 65 percent of the flood damage in the watershed. Since a dependable feed supply is essential to a beef cattle production enterprise, these crop losses due to flooding are of even greater importance than just the value of the crop.

Other agricultural damages, such as fence damage, loss of personal farm property and equipment are quite extensive and amounts to an average annual sum of $23,200.

There are 12.5 miles of roads and 42 major bridges in the floodplain subject to average annual damage of $24,200. Flood flows wash away road surfacing, scour road shoulders, and deposit sediment in roadside ditches.

Small frequent floods, local in character, cause considerable damage and inconvenience to individual farmers in the area of their occurrence. Major floods affect everyone in the area because of damage to roads, bridges, transportation, and loss of business to those serving the agricultural community. Such indirect losses under present conditions are estimated to average $25,100 annually.

Sediment Damage

Sediment yields are low due to the high percentage of pastureland and the relatively low erodibility of upland soils. Sediments are mainly silts and clays and have only slight detrimental effects on valley lands.

Erosion Damage

Land damage, primarily from floodplain scour due to high velocity flood flows occurring on row crops or on freshly worked land, is quite severe throughout the length of the floodplain. Frequent flooding has caused scour damage on about 25 percent of the floodplain cropland with productive capacity reduced by a weighted average of 23 percent. Under present conditions the average annual erosion damage to the floodplain is $26,900.

Problems Relating to Water Management

Municipal water supply needs were discussed with city officials of Leon and Beaumont. They decided their needs for additional water were not sufficient to warrant further expenditures at this time.

No individual landowner or group of landowners have indicated sufficient interest in irrigation water to warrant its inclusion in any of the planned structures.

Drainage is not a problem in this watershed.

PROJECTS OF OTHER AGENCIES

The Corps of Engineers, under authority of the House of Representatives Public Works Committee Resolution, adopted 16 October 1951, is currently making a detailed study of the Walnut River Basin. The plan of improvement under consideration includes El Dorado, Douglass, and Towanda Reservoirs, modification of the Winfield levee, and a local protection project on the West Branch of the Walnut River at El Dorado. Douglass Reservoir on Little Walnut Creek, located just below the junction of Little Walnut River and Hickory Creek is being considered for flood control, water supply, recreation, and fish and wildlife purposes. The future water supply needs of El Dorado, Augusta, Winfield, and Arkansas City, together with low flow augmentation, can only partially be met by conservation storages included in the current plans for El Dorado, Douglass and Towanda Reservoirs.

Douglass reservoir is tentatively planned with the conservation pool at elevation 1,258.0. At this elevation the water would back up Little Walnut River channel about five miles and Hickory Creek about three miles above the junction of the two streams.

The physical plan of Little Walnut-Hickory Watershed would not be affected but the monetary evaluation would change if Douglass Reservoir was constructed. Two thousand one hundred acres of floodplain, with potential flood prevention benefits of $19,900, will be covered by the reservoir. This loss of benefits would be offset to some degree by benefits to the reservoir through reduction in sedimentation. An additional $29,200 of benefits accrue in areas below the proposed Douglass Reservoir. If Douglass Reservoir is built, joint benefits would be allocated equitably to both projects.

BASIS FOR PROJECT FORMULATION

A high degree of flood protection cannot be provided to the entire floodplain area. The reasons for this are: 1. Floodplain development extends from the outlet end to within a very few miles of the watershed divide; 2. The drainage pattern is such that a large percent of the drainage area cannot be economically controlled by reservoirs on minor tributary streams, and; 3. Channel improvement is neither economical or practical because of the geology of the area.

To protect the upper reaches of the watershed it was necessary to place structures immediately above the areas where significant flood damages occur.

Protection of the mainstem reaches in the central part of the watershed would require mainstem reservoirs located downstream from important damage areas and also on the major tributaries entering below the mainstem structures. Such a system without the upstream structures would afford no protection to the upper reaches and would have adverse effects on the reaches in which the mainstem structures were placed. This system was not economically justified with both upstream and mainstem structures in place. Without upstream protection it was totally unacceptable to local people.

To give the lower reaches of the watershed a high degree of protection, mainstem structures in series would be needed. These were not acceptable locally and would be incompatible with the proposed Douglass Reservoir.

A system of economically justified tributary structures were formulated to protect as much of the watershed as possible. The system provides a high degree of flood protection in the upper reaches ranging to a lower degree at the watershed outlet. Local people would rather forgo additional flood protection than to suffer the adverse effects of additional mainstem structures.

Land treatment and floodwater retarding reservoirs were selected as the works of improvement to accomplish watershed protection and flood prevention in keeping with the desires of local sponsors. Channel improvement would be impractical for this watershed because enlargement of existing channels into limestone would have excessive costs for channel excavation.

WORKS OF IMPROVEMENT TO BE INSTALLED

The works of improvement to be installed consist of the necessary land treatment measures for watershed protection and 40 floodwater retarding structures.

Land Treatment Measures

The application of land treatment measures is essential to a sound and continuing watershed protection and flood prevention program. This objective is attained through the establishment and maintenance of all soil, water, and plant management practices essential to proper land use.

Land treatment measures include vegetative practices such as proper range use, conservation cropping systems, range seeding, pasture planting, and structural practices such as gradient terraces, grassed waterways, diversions, farm ponds, and grade stabilization structures. The vegetative practices improve soil conditions allowing more water to be retained by the soil hence reducing runoff and erosion. The structural practices also retard runoff and reduce erosion. In order to reduce runoff and sediment from forest sites, such areas must support fully stocked stands of trees with an undisturbed forest floor or ground cover. To attain these objectives and at the same time increase productivity of these areas, the following forestry measures are planned:

A. Tree and shrub planting

   1. Woodland planting
   2. Structure planting

B. Woodland protection

C. Timber stand improvement

The amounts and the estimated costs of the measures are shown in Table 1. The estimated total cost of planning and installing land treatment measures is $434,700. Public Law 566 funds will be furnished in the amount of $74,000 to provide technical assistance to accelerate current program. Funds from other sources will be provided in the amount of $360,700 for installing these measures.

Land treatment measures alone will not be sufficient to provide the desired control of runoff. Structural measures described below will be installed to supplement the land treatment measures in reducing floodwater and land damage.

Structural Measures

A system of 40 floodwater retarding structures will be installed at the locations shown on the project map. Features of typical floodwater retarding structures with principal spillways having single or two stage inlets are shown on drawings following page 42. Structure data by structure and in total is presented in Table 3.

This system will control the runoff from 34 percent of the total watershed area. The area controlled is 59,027 acres (92.23 square miles) and averages 1,475 acres drainage area per structure.

The system of structures will have capacity to temporarily store 17,075 acre feet of floodwater. This is equivalent to 3.47 inches of runoff from the controlled area. In addition the structures are planned to store the expected 50-year accumulation of sediment from their drainage areas. This amounts to 2,647 acre feet of sediment storage and is equivalent to 0.54 inches per acre from the total controlled area.

The floodwater retarding structures will be earth dams with principal spillways of metal or reinforced concrete pipe and vegetated or rock emergency spillways. The larger structures will have principal spillways of reinforced concrete pipe with uncontrolled two-stage inlets. These inlets will provide average release rates of 10 c.s.m. through the first stage with an additional 15 c.s.m. through the second stage. The second stage will operate with runoff in excess of the 20 percent chance storm. The smaller structures will have principal spillway of corrugated metal pipe with uncontrolled single stage inlets with average release rates of 15 c.s.m. The emergency spillways are planned to operate on storms exceeding the magnitude of the 4 percent chance storm.

The floodwater retarding structures will be installed at an estimated total cost of $2,261,000. The estimated cost of individual structures is shown in Table 2.

EXPLANATION OF INSTALLATION COSTS

Public Law 566 costs for structural measures for flood prevention include construction cost and installation services costs. Construction

cost includes general construction and vegetative establishment work of the character normally performed by contractors. Installation services include engineering, administrative services and overhead costs of programming and supervision.

Engineering services include all direct and related costs of the services of engineers and geologists for surveys, geologic site investigations and soil mechanics, structure design, construction plans and specifications, construction engineering and supervision. Administrative service includes assistance made available to the local contracting organization, if requested, to help in preparing invitations to bid and in awarding construction contracts. Overhead costs include administration and program supervision at all levels concerned with conduct of the program.

Engineering service costs were computed as a percent of construction cost where functions are proportional to construction cost. Flat rates were used in computing functions with relatively fixed costs. Other installation services costs were computed as 8 percent of construction cost.

Construction cost estimates in this plan are based on computation of quantities derived from survey data at each site using unit costs for similar work on watershed projects currently under construction with a contingency allowance of 12 percent. At the time of project installation, additional surveys will be needed at the dam sites as a basis for structural design and construction cost estimates. Geologic drilling and soil mechanics tests and analysis will be performed to verify site and foundation conditions. Reservoir storage volumes will be computed from topographic maps made during work plan preparation.

Land, easement and right-of-way values were determined by the Board of Directors of the Little Walnut-Hickory Watershed Joint District. The agreed on cost estimates were based on current land values of $75.00 per acre for grassland, $100 per acre for upland cropland, and $125 for bottomland cropland. It is recognized that such values may not coincide with actual out-of-pocket costs to the local sponsoring organization because some easements and rights-of-way may be obtained by donation. The estimated cost of relocating or modifying utilities was obtained from the owners of these facilities. The cost of road and bridge modifications was developed in consultation with county engineers.

Contract administration costs of the local contracting organization will include cost of mailing bid invitations, salary, if any, and expenses of the contracting officer in administering construction contracts. Contract administration costs were estimated on the basis of experience of other watershed districts in Kansas who have carried out construction work.

The cost of applying land treatment measures is based on current costs of applying such measures under going programs.

The estimated total P.L. 566 cost and other obligations by fiscal years during the project installation period are as follows:

Fiscal Year	P.L. 566 Costs	Other Costs
First	$302,800	$99,800
Second	$546,000	$127,500
Third	$464,700	$127,500
Fourth	$499,300	$127,500
Fifth	$300,700	$99,900

EFFECTS OF WORKS OF IMPROVEMENT

The flood prevention program will directly benefit 171 owners of floodplain land within the watershed.

The program of land treatment and structural measures will reduce flood damages ranging from 100 percent immediately below floodwater retarding structures to 37 percent at the outlet of the watershed. The program will accomplish a 53 percent reduction in average annual flood damages within the watershed. The area benefited by reach is as follows:

Reach	Area Benefited Acres	Reach	Area Benefited Acres
1	1,720	10	660
2	850	11	610
3	860	12	213
4	1,400	13	1,045
5	480	14	845
6	512	14A	232
7	1,265	15	366
8	480	16	565
8A	153	17	705
8B	208	18	234
9	375		

In the event Douglass Reservoir is authorized and constructed, it would inundate the benefit area in reaches 2 and 3 and about 1/3 of reach 13. The benefits from Little Walnut-Hickory Watershed below reaches 4 and 13 would be limited to a reduction of sedimentation in the Douglass Reservoir and a share of the downstream benefits as to the effect that the watershed program has on the floodwater capacity and operation of this capacity in Douglass Reservoir.

Sixty-six percent of the floodplain area without Douglass Reservoir and seventy-two percent of the floodplain area above Douglass Reservoir will be satisfactorily protected from the 4-year frequency flood event. Flooding of more than one foot depth will occur on the remaining area. The land use in the flooded zone includes a substantial amount of woodland.

The reduction in the depth and frequency of flooding will substantially reduce crop losses on the floodplain which occurs from velocity of flood flows, drowning due to duration of floodwater on the land, and deposition of sediment and debris. In addition, the reduction in the flood hazard will induce farmers to use more fertilizer, improved crop varieties and soil building rotations. They will also be able to perform tillage, planting, and harvesting operations on a more timely basis with resultant improvement in production.

Losses in productivity due to removal of soil by floodplain scour will be substantially reduced. The reduction in flooding will likewise make it possible to restore productivity on previously damaged land at a more rapid rate.

Reduction in frequency of flooding will permit the conversion of 486 acres of floodplain land from brushy pasture and timber to cropland. This change in use of floodplain land will compensate in part for the conversion of cropland to range use in the upland area of the watershed.

A substantial reduction in costs of maintaining roads and bridges on the floodplain will be realized. The reduction in cost in repairing flood damages will release road and bridge funds for use in improving and modernizing the road system.

Works of improvement in Little Walnut-Hickory will provide important benefits outside the watershed when considered jointly with other works of improvement proposed on the Walnut River. Off-project benefits will accrue to 31,450 acres of floodplain lands and to the city of Winfield.

The Bureau of Sport Fisheries and Wildlife, in cooperation with the Kansas Forestry, Fish and Game Commission made a reconnaissance study of the proposed project on fish and wildlife habitat. They report that installation of the structures will, in general, benefit the fish and wildlife resources.

Stream fishing will be improved as a result of more stabilized flows below the floodwater retarding structures. Permanent storage pools in the floodwater retarding structures will increase the fishing opportunities in the watershed. Increased water area of some 660 acres widely distributed over the watershed will benefit waterfowl by providing resting areas and some winter habitat. Upland game birds will be displaced from the permanent pool area of the detention structures, but terrestrial species will benefit from flood reduction in the protected bottom lands where not intensively cultivated.

PROJECT BENEFITS

Flood prevention benefits from the project measures are estimated to be $168,500, of which $5,200 are attributable to the land treatment measures and $163,300 accrue to the floodwater retarding structures. Individual items of benefit are shown in Tables 5 and 6.

Benefits from reduction in floodwater damage to crops averages $98,800 annually and accounts for 64 percent of the flood prevention benefits within the watershed. Benefits from more intensive use of land through improved rotations, more timely operations, and added use of fertilizer average $13,000 annually and benefit from changed land use adds $15,800 within the watershed.

Benefits from reduced damage to floodplain land by scour will average $10,100 annually, accounting for 7 percent of the total on-project flood prevention benefits. Benefits from reduction in floodwater damage to roads and bridges amount to $15,700 and similar benefits to other agricultural property such as fences, stored feed, buildings and other farm improvements is $14,800 on an average annual basis.

Indirect benefits realized from reduction in interruptions of travel, halting or delays in mail and school bus routes amount to $13,700 on an average annual basis within the watershed.

Flood prevention benefits outside the watershed will average $15,400 annually. These benefits are assignable to this watershed based on the evaluation of benefits to the Walnut River floodplain which accrue from works of improvement including the two upper Corps reservoirs and four proposed watershed projects achieving joint benefits in this area. These benefits stem in large measure from reduction in floodwater damage to crops on the floodplain and to the city of Winfield.

If Douglass reservoir is constructed, the benefits from watershed works of improvement, as now computed, would be reduced by $19,900 due to inundation of lands in reaches 2, 3, and 13. Benefits in reach 1 amounting to $13,800 and benefits to the area below the watershed boundary amounting to $15,400 will be modified if Douglass reservoir is constructed. The above benefits total $49,100. The construction of Douglass Reservoir would increase the level of flood protection for the floodplain below the Douglass site. The value of the benefits which could be accredited back to the watershed works of improvement are non-obtainable at this time.

Benefits which result from increased business in the community, the fact that roads are open and usable, the freedom from fear of flooding, and improvement in fish, wildlife, and recreational opportunities are important to the community, the region and the Nation. These benefits were not evaluated monetarily or used in project justification.

COMPARISON OF BENEFITS AND COSTS

The average annual cost of structural measures, including installation, operation and maintenance is $90,000. When the project is completely installed, the structural measures are expected to produce average annual benefits of $192,100. Therefore, the project will produce benefits of $2.10 for each dollar of equivalent cost.

PROJECT INSTALLATION

The works of improvement will be installed in a five-year period. Federal assistance for carrying out the works of improvement on non-Federal land as described in this work plan will be provided under authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress; 68 Stat. 666) as amended.

Land Treatment Measures

Land treatment measures listed in Table 1 will be established on the land by the farm owners and operators in cooperation with the Butler and the Greenwood County Soil Conservation Districts. The cost of applying these measures will be borne by the owners and operators of the land. The Soil Conservation Service and the State Extension Forester under cooperative agreement with the Forest Service will provide technical assistance in planning and establishing land treatment measures. Technical assistance will be accelerated to assure application of the planned measures within the five-year installation period of the project.

The Extension Service will assist in carrying out the educational phase of the program by the dissemination of general information in cooperation with the governing bodies of the Soil Conservation and Watershed District boards. The Farmers Home Administration's Soil and Water Loan Program will be available to eligible farmers in the area. The County Agricultural Stabilization Conservation Committees will cooperate with the governing bodies of the Soil Conservation Districts to accelerate Agricultural Conservation Program financial assistance for those practices which will accomplish the conservation objectives. The Butler and Greenwood County Soil Conservation Districts will encourage landowners and operators within the Little Walnut-Hickory Watershed to adopt and carry out the soil and water conservation measures on their farms.

Structural Measures

Little Walnut-Hickory Watershed Joint District will contract for the construction of the 40 floodwater retarding structures. All structural measures will be installed through construction contracts awarded on the basis of competitive bidding. Separate contracts will be awarded for general construction and for vegetative establishment. The local sponsoring organization will appoint a contracting officer and will bear the cost of contract administration.

The watershed district will obtain all land rights, easements, and rights-of-way needed for installation of the 40 floodwater retarding structures. The watershed district will make arrangements with the County commissioners for abandonment, relocation or modification of any county roads requiring such action. The watershed district will likewise arrange for any relocation or modification to pipelines, communication lines or other public utilities which are necessary in connection with project installation. The watershed district has, and agrees to use, the legal authority and resources necessary to obtain all land, easements and rights-of-way for the project.

After Federal assistance is authorized for installation of the project, the Soil Conservation Service will furnish engineering services to prepare construction plans and specifications for structural measures for flood prevention. Construction can then be started on structures for which all land rights have been obtained, P.L. 566 funds are available and local sponsoring organizations have complied with State laws relating to approval of construction plans.

FINANCING PROJECT INSTALLATION

The Little Walnut-Hickory Watershed Joint District was created and validated in accordance with the Kansas Watershed District Act as amended. The watershed district has all the necessary authority and powers to finance and carry out watershed improvements. These powers include the right to accept contributions, levy taxes, make assessments against land specially benefited, issue bonds, and exercise the right of eminent domain.

The expenses of organizing the district have been paid and current general expenses are being met by an annual ad valorem tax levy.

The watershed district has been furnished land rights work maps for all structural measures as a basis for contacting landowners and appraising costs to the district. The Board of Directors believe, based on contacts with owners, that most of the needed land rights will be donated. Land rights which must be purchased will be financed by a general tax levy.

Funds for construction costs will be provided to the local sponsoring organizations as grants-in-aid through project agreements for construction executed with the Soil Conservation Service. A project agreement will be executed for each group of structures to be included in a construction contract.

The furnishing of technical assistance, installation services, and grants-in-aid for construction by the Soil Conservation Service is contingent upon appropriation of funds for these purposes.

The Soil Conservation Districts will seek such allocation of Agricultural Conservation Program funds as are needed to cost share on land treatment measures to meet project objectives within the Watershed. Technical assistance available from the Soil Conservation Service in its program of assistance to soil conservation districts will continue at current rates.

The State Extension Forester, by cooperative agreement with the Forest Service, will share the cost of furnishing accelerated forestry technical assistance equally with P.L. 566.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

The land treatment measures will be maintained by the landowners and operators of the farms on which the measures are installed under agreements

with the soil conservation districts serving the area. Representatives of the soil conservation districts will make periodic inspections of the land treatment measures to determine maintenance needs and will encourage landowners to perform needed maintenance.

Structural Measures

An agreement providing for operation and maintenance of the structural measures will be executed by the local sponsoring organizations before Federal construction funds are made available.

The 40 floodwater retarding structures will be operated and maintained by the Little Walnut-Hickory Watershed Joint District. All structural measures will be inspected by representatives of the Watershed District and the Soil Conservation Service at least annually and after each heavy-runoff-producing storm. Items of inspection will include, but not be limited to, the condition of the principal spillway and its appurtenances, the emergency spillway, the earth fill, the vegetative cover of the earth fill and emergency spillway, and any fences installed as a part of the floodwater retarding structures. The Little Walnut-Hickory Watershed Joint District will maintain a record of maintenance inspections.

The estimated average annual operation and maintenance cost of the floodwater retarding structures is $5,500. The necessary maintenance will be accomplished through contributed labor and equipment and/or hired labor and equipment. Funds for accomplishing the maintenance work will be obtained from an annual tax levy within the district.

Provisions will be made for free access of District, State and Federal representatives to inspect the structural system at any time.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Little Walnut-Hickory Watershed, Kansas

Installation Cost Item	Unit	Number Non-Fed. Land	Estimated Cost (Dollars) 1/ P.L. 566	Other	Total
Land Treatment					
Soil Conservation Service					
Conservation Cropping System	Ac.	2,700		67,500	67,500
Proper Range Use	Ac.	7,000		600	600
Range Seeding	Ac.	1,000		21,400	21,400
Pasture Planting (tame)	Ac.	440		10,200	10,200
Grassed Waterways	Ac.	353		52,900	52,900
Diversions	Mi.	25		13,300	13,300
Grade Stabilization Structures	No.	51		42,300	42,300
Farm Ponds	No.	35		32,100	32,100
Terraces - Gradient	Mi.	218		80,600	80,600
Technical Assistance			70,700	18,500	89,200
SCS Subtotal			70,700	339,400	410,100
Forest Service					
Tree and Shrub Planting	Ac.	180		15,300	15,300
Woodland Protection	Ac.	300		600	600
Woodland Improvement	Ac.	175		2,100	2,100
Technical Assistance			3,300	3,300	6,600
FS Subtotal			3,300	21,300	24,600
TOTAL LAND TREATMENT			74,000	360,700	434,700
STRUCTURAL MEASURES					
Construction					
Floodwater Retarding Structures	No.	40	1,515,600		1,515,600
Installation Services					
Engineering			402,600		402,600
Other			121,300		121,300
Subtotal-Installation			523,900		523,900
Other Costs					
Land, Easements and R/W				209,500	209,500
Administration of Contracts				12,000	12,000
Subtotal - Other				221,500	221,500
TOTAL STRUCTURAL MEASURES			2,039,500	221,500	2,261,000
TOTAL PROJECT			2,113,500	582,200	2,695,700
SUMMARY					
Subtotal SCS			2,110,200	560,900	2,671,100
Subtotal FS			3,300	21,300	24,600
TOTAL PROJECT			2,113,500	582,200	2,695,700

1/ Price base 1962

March 1963

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT

Little Walnut-Hickory Watershed, Kansas

Measures	Unit	Applied to Date	Total Cost (Dollars) 1/
LAND TREATMENT			
Conservation Cropping System	Acre	23,400	585,100
Proper Range Use	Acre	101,700	9,200
Range Seeding	Acre	500	10,500
Pasture Planting (tame)	Acre	3,500	79,600
Grass Waterways	Acre	127	19,100
Diversions	Mile	23	12,100
Grade Stabilization Structures	No.	8	6,600
Farm Ponds	No.	642	588,700
Terraces - Gradient	Mi.	158	58,400
Total			1,369,300

1/ Price base 1962

March 1963

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Little Walnut-Hickory Watershed, Kansas

Sheet 1 of 2

Structure Site No.	Installation Cost - P.L. 566 Funds				Installation Cost-Other Funds			Total Installation Cost
	Construction	Installation Services		Total P.L. 566	Other		Total Other	
		Engineering	Other		Adm. of Contracts	Easements & R/W		
1	48,500	13,900	3,900	66,300	300	2,300	2,600	68,900
2	54,400	14,800	4,400	73,600	300	9,300 1/	9,600	83,200
3	20,800	5,700	1,700	28,200	300	3,100 2/	3,400	31,600
4	54,600	14,900	4,400	73,900	300	4,700	5,000	78,900
5	15,700	4,900	1,300	21,900	300	1,600	1,900	23,800
6	21,100	5,800	1,700	28,600	300	2,800 3/	3,100	31,700
7	64,100	15,900	5,100	85,100	300	6,600 4/	6,900	92,000
8	49,400	14,100	4,000	67,500	300	6,000	6,300	73,800
9	67,800	16,100	5,400	89,300	300	46,100 5/	46,400	135,700
10	19,600	5,500	1,500	26,600	300	1,900	2,200	28,800
11	61,800	15,700	4,900	82,400	300	6,200	6,500	88,900
12	11,600	4,300	900	16,800	300	1,500 6/	1,800	18,600
13	56,100	15,000	4,500	75,600	300	8,100 7/	8,400	84,000
14	14,300	4,800	1,100	20,200	300	1,600	1,900	22,100
15	40,500	12,300	3,200	56,000	300	2,200	2,500	58,500
16	24,200	7,500	1,900	33,600	300	2,000	2,300	35,900
17	30,200	6,900	2,400	39,500	300	4,100	4,400	43,900
18	23,500	6,100	1,900	31,500	300	2,100	2,400	33,900
19	30,000	6,900	2,400	39,300	300	4,600	4,900	44,200
20	68,800	16,300	5,500	90,600	300	13,500 8/	13,800	104,400
21	72,300	16,500	5,800	94,600	300	12,900 9/	13,200	107,800
22	32,200	8,700	2,600	43,500	300	6,700 10/	7,000	50,500
23	33,400	10,800	2,700	46,900	300	1,800	2,100	49,000
24	18,100	5,300	1,500	24,900	300	1,600	1,900	26,800
25	12,200	4,400	1,000	17,600	300	1,100	1,400	19,000

March 1963

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION

Little Walnut-Hickory Watershed, Kansas

Sheet 2 of 2

Structure Site No.	Installation Cost - P.L. 566 Funds				Installation Cost-Other Funds			Total Installation Cost
	Construction	Installation Services		Total P.L. 566	Other		Total Other	
		Engineering	Other		Adm. of Contracts	Easements & R/W		
26	29,900	8,300	2,400	40,600	300	3,100	3,400	44,000
27	16,500	5,100	1,300	22,900	300	1,400	1,700	24,600
28	72,700	16,600	5,800	95,100	300	5,300	5,600	100,700
29	107,200	19,100	8,600	134,900	300	9,200	9,500	144,400
30	23,300	7,200	1,900	32,400	300	2,300	2,600	35,000
31	32,500	10,600	2,600	45,700	300	2,600 11/	2,900	48,600
32	21,600	5,800	1,700	29,100	300	3,200 12/	3,500	32,600
33	16,300	5,000	1,300	22,600	300	2,300 13/	2,600	25,200
34	24,100	6,200	1,900	32,200	300	2,900	3,200	35,400
35	35,400	11,200	2,800	49,400	300	3,400	3,700	53,100
36	38,000	11,700	3,000	52,700	300	2,500 14/	2,800	55,500
37	60,200	15,600	4,800	80,600	300	7,300 15/	7,600	88,200
38	26,100	7,800	2,100	36,000	300	2,400	2,700	38,700
39	49,100	14,100	4,000	67,200	300	5,600	5,900	73,100
40	17,500	5,200	1,400	24,100	300	1,600	1,900	26,000
TOTAL	1,515,600	402,600	121,300	2,039,500	12,000	209,500	221,500	2,261,000

1/ Includes $4,500 to raise road and relocate power and telephone lines
2/ Includes $100 to relocate power pole
3/ Includes $900 to raise road
4/ Includes $250 to relocate windmill
5/ Includes $38,600 to weight pipeline
6/ Includes $150 to relocate power poles
7/ Includes $2,650 to raise road and move 3 power poles
8/ Includes $7,000 to raise road
9/ Includes $6,185 to raise road
10/ Includes $3,000 to raise road and relocate power poles
11/ Includes $200 to relocate power poles
12/ Includes $250 to relocate windmill
13/ Includes $100 to relocate power pole
14/ Includes $300 to raise road
15/ Includes $2,500 to raise road

March 1963

TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES

Little Walnut-Hickory Watershed, Kansas

Sheet 1 of 11

ITEM	UNIT	STRUCTURE NUMBER 1	2	3	4
Drainage Area	Sq. Mi.	1.84	3.40	1.56	4.39
Storage Capacity					
Sediment	Ac. Ft.	54	100	42	129
Floodwater	Ac. Ft.	363	625	292	808
Total	Ac. Ft.	417	725	334	937
Between High and Low Stages	Ac. Ft.	250	462	2/	597
Surface Area					
Sediment Pool	Acres	12	20	12	26
Floodwater Pool	Acres	46	77	52	94
Volume of Fill	Cu. Yds.	57,652	72,392	43,640	62,173
Elevation Top of Dam	Feet	1,401.6	1,387.5	1,383.0	1,422.0
Maximum Height of Dam	Feet	31.2	32.5	26.4	34.0
Emergency Spillway					
Crest Elevation	Feet	1,395.5	1,382.5	1,379.3	1,417.0
Bottom Width	Feet	60	40	40	40
Type	--	Rock	Rock	Rock	Rock
Percent Chance of Use	--	2	4	4	4
Average Curve No. - Cond. II	--	79	79	79	79
Emergency Spillway Hydrograph					
Storm Rainfall (6 hr.)	Inches	8.62	6.14	6.02	6.1
Storm Runoff	Inches	6.09	3.81	3.70	3.77
Velocity of Flow (Vc) 1/	Ft./Sec.	6.3	2.4	2.7	3.0
Discharge Rate 1/	c.f.s.	460	16	24	32
Maximum W. S. Elevation 1/	Feet	1,398.05	1,382.95	1,379.9	1,417.8
Freeboard Hydrograph					
Storm Rainfall (6 hr.)	Inches	14.6	9.22	8.62	9.1
Storm Runoff	Inches	11.83	6.65	6.09	6.54
Velocity of Flow (Vc) 1/	Ft./Sec.	10.5	8.6	6.7	9.0
Discharge Rate 1/	c.f.s.	2,160	776	368	864
Maximum W. S. Elevation 1/	Feet	1,401.6	1,386.8	1,381.7	1,421.6
Principal Spillway					
Capacity - Low Stage	c.f.s.	18.4	34	23.2	43.9
Capacity - High Stage	c.f.s.	46	85	2/	109.8
Capacity Equivalents					
Sediment Volume	Inches	0.55 4/	0.55 4/	0.5	0.55 4/
Detention Volume	Inches	3.70	3.45	3.52	3.45
Spillway Storage	Inches	3.4	2.65	2.7	2.35
Class of Structure	--	b	a	a	a

1/ Maximum during passage of hydrograph
2/ Single stage CMP principal spillway
3/ Emergency spillway hydrograph is contained below crest of emergency spillway
4/ 0.05" sediment is stored above the principal spillway

March 1963

TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES

Little Walnut-Hickory Watershed, Kansas

Sheet 2 of 11

ITEM	UNIT	STRUCTURE NUMBER 5	6	7	8
Drainage Area	Sq. Mi.	0.77	0.88	3.85	3.64
Storage Capacity					
Sediment	Ac. Ft.	21	23	113	107
Floodwater	Ac. Ft.	145	165	708	669
Total	Ac. Ft.	166	188	821	776
Between High and Low Stage	Ac. Ft.	2/	2/	524	495
Surface Area					
Sediment Pool	Acres	6	8	33	31
Floodwater Pool	Acres	22	27	118	105
Volume of Fill	Cu. Yds.	27,314	42,854	104,005	65,491
Elevation Top of Dam	Feet	1,414.0	1,426.2	1,530.9	1,502.8
Maximum Height of Dam	Feet	24.0	21.2	20.9	28.8
Emergency Spillway					
Crest Elevation	Feet	1,410.5	1,422.7	1,525.9	1,497.8
Bottom Width	Feet	40	40	40	40
Type	--	Rock	Rock	Rock	Rock
Percent Chance of Use	--	4	4	4	4
Average Curve No. - Cond. II	--	79	79	79	79
Emergency Spillway Hydrograph					
Storm Rainfall (6 hr.)	Inches	6.02	6.02	6.02	6.02
Storm Runoff	Inches	3.70	3.70	3.70	3.70
Velocity of Flow (Vc)1/	Ft./Sec.	3/	3/	2.8	2.7
Discharge Rate1/	c.f.s.	3/	3/	28	24
Maximum W. S. Elevation1/	Feet	3/	3/	1,526.6	1,498.4
Freeboard Hydrograph					
Storm Rainfall (6 hr.)	Inches	8.62	8.62	8.62	8.62
Storm Runoff	Inches	6.09	6.09	6.09	6.09
Velocity of Flow (Vc)1/	Ft./Sec.	5.9	5.9	7.1	7.3
Discharge Rate1/	c.f.s.	256	256	460	488
Maximum W. S. Elevation1/	Feet	1,412.8	1,425.0	1,529.1	1,501.1
Principal Spillway					
Capacity - Low Stage	c.f.s.	11.6	14.2	38.5	36.4
Capacity - High Stage	c.f.s.	2/	2/	99.4	91.1
Capacity Equivalents					
Sediment Volume	Inches	0.5	0.5	0.55 4/	0.55 4/
Detention Volume	Inches	3.52	3.52	3.45	3.45
Spillway Storage	Inches	2.18	2.50	2.70	3.40
Class of Structure	--	a	a	a	a

1/ Maximum during passage of hydrograph
2/ Single stage CMP principal spillway
3/ Emergency spillway hydrograph is contained below crest of emergency spillway
4/ 0.05" sediment is stored above the principal spillway

March 1963

TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES

Little Walnut-Hickory Watershed, Kansas

Sheet 3 of 11

ITEM	UNIT	STRUCTURE NUMBER 9	10	11	12
Drainage Area	Sq. Mi.	5.34	0.95	3.86	0.56
Storage Capacity					
Sediment	Ac. Ft.	157	25	113	15
Floodwater	Ac. Ft.	983	179	710	105
Total	Ac. Ft.	1,140	204	823	120
Between High and Low Stages	Ac. Ft.	727	2/	525	2/
Surface Area					
Sediment Pool	Acres	39	8	32	5
Floodwater Pool	Acres	149	27	116	21
Volume of Fill	Cu. Yds.	102,799	31,439	89,677	22,120
Elevation Top of Dam	Feet	1,515.4	1,440.2	1,523.2	1,457.9
Maximum Height of Dam	Feet	28.9	24.5	27.2	18.4
Emergency Spillway					
Crest Elevation	Feet	1,510.4	1,436.7	1,518.2	1,454.4
Bottom Width	Feet	40	40	40	40
Type	--	Veg.	Rock	Rock	Rock
Percent Chance of Use	--	4	4	4	4
Average Curve No. - Cond. II	--	79	79	79	79
Emergency Spillway Hydrograph					
Storm Rainfall (6 hr.)	Inches	6.02	6.02	6.02	6.02
Storm Runoff	Inches	3.70	3.70	3.70	3.70
Velocity of Flow (Vc) 1/	Ft./Sec.	2.4	3/	2.7	3/
Discharge Rate 1/	c.f.s.	16	3/	24	3/
Maximum W. S. Elevation 1/	Feet	1,510.8	3/	1,518.8	3/
Freeboard Hydrograph					
Storm Rainfall (6 hr.)	Inches	8.62	8.62	8.62	8.62
Storm Runoff	Inches	6.09	6.09	6.09	6.09
Velocity of Flow (Vc) 1/	Ft./Sec.	6.8	6.4	7.4	5.0
Discharge Rate 1/	c.f.s.	392	320	488	160
Maximum W. S. Elevation 1/	Feet	1,513.3	1,439.3	1,521.5	1,456.2
Principal Spillway					
Capacity - Low Stage	c.f.s.	53.4	14.5	38.6	8.4
Capacity - High Stage	c.f.s.	133.5	2/	96.5	2/
Capacity Equivalents					
Sediment Volume	Inches	0.55 4/	0.5	0.55 4/	0.5
Detention Volume	Inches	3.45	3.52	3.45	3.52
Spillway Storage	Inches	4.65	1.90	3.55	2.40
Class of Structure	--	a	a	a	a

1/ Maximum during passage of hydrograph
2/ Single stage CMP principal spillway
3/ Emergency spillway hydrograph is contained below crest of emergency spillway
4/ 0.05" sediment is stored above the principal spillway

March 1963

TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES

Little Walnut-Hickory Watershed, Kansas

Sheet 4 of 11

ITEM	UNIT	STRUCTURE NUMBER 13	14	15	16
Drainage Area	Sq. Mi.	3.93	0.96	1.94	1.51
Storage Capacity					
Sediment	Ac. Ft.	115	25	62	40
Floodwater	Ac. Ft.	723	180	347	274
Total	Ac. Ft.	838	205	409	314
Between High and Low Stages	Ac. Ft.	534	2/	254	2/
Surface Area					
Sediment Pool	Acres	24	8	13	9
Floodwater Pool	Acres	100	27	40	34
Volume of Fill	Cu. Yds.	74,601	27,339	47,514	43,424
Elevation Top of Dam	Feet	1,475.0	1,403.2	1,404.0	1,421.0
Maximum Height of Dam	Feet	30.5	25.2	32.0	30.0
Emergency Spillway					
Crest Elevation	Feet	1,470.0	1,399.6	1,399.0	1,417.2
Bottom Width	Feet	40	40	40	40
Type	--	Rock	Rock	Rock	Rock
Percent Chance of Use	--	4	4	4	4
Average Curve No. - Cond. II	--	79	79	79	78
Emergency Spillway Hydrograph					
Storm Rainfall (6 hr.)	Inches	6.02	6.02	6.02	6.02
Storm Runoff	Inches	3.70	3.70	3.70	3.61
Velocity of Flow (Vc)1/	Ft./Sec.	2.5	3.1	3.6	3.3
Discharge Rate1/	c.f.s.	20	40	60	40
Maximum W. S. Elevation1/	Feet	1,470.5	1,400.5	1,400.1	1,418.1
Freeboard Hydrograph					
Storm Rainfall (6 hr.)	Inches	8.62	8.62	8.62	8.62
Storm Runoff	Inches	6.09	6.09	6.09	5.97
Velocity of Flow (Vc)1/	Ft./Sec.	7.9	7.6	7.7	7.3
Discharge Rate1/	c.f.s.	620	540	592	488
Maximum W. S. Elevation1/	Feet	1,473.8	1,403.1	1,402.7	1,420.5
Principal Spillway					
Capacity - Low Stage	c.f.s.	39.3	14.9	19.4	23.7
Capacity - High Stage	c.f.s.	98.3	2/	50.4	2/
Capacity Equivalents					
Sediment Volume	Inches	0.55 4/	0.5	0.6 4/	0.5
Detention Volume	Inches	3.45	3.52	3.35	3.40
Spillway Storage	Inches	2.75	2.2	2.15	1.50
Class of Structure	--	a	a	a	a

1/ Maximum during passage of hydrograph
2/ Single stage CMP principal spillway
3/ Emergency spillway hydrograph is contained below crest of emergency spillway
4/ 0.05" sediment is stored above the principal spillway

March 1963

TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES

Little Walnut-Hickory Watershed, Kansas

Sheet 5 of 11

ITEM	UNIT	STRUCTURE NUMBER 17	18	19	20
Drainage Area	Sq. Mi.	2.38	1.32	2.30	4.37
Storage Capacity					
Sediment	Ac. Ft.	70	35	67	128
Floodwater	Ac. Ft.	412	229	398	804
Total	Ac. Ft.	482	264	465	932
Between High and Low Stages	Ac. Ft.	2/	2/	2/	594
Surface Area					
Sediment Pool	Acres	19	11	18	33
Floodwater Pool	Acres	67	34	61	125
Volume of Fill	Cu. Yds.	73,925	42,983	71,008	93,698
Elevation Top of Dam	Feet	1,487.4	1,449.4	1,467.0	1,526.8
Maximum Height of Dam	Feet	25.4	29.4	29.0	27.8
Emergency Spillway					
Crest Elevation	Feet	1,483.8	1,445.8	1,463.0	1,521.8
Bottom Width	Feet	40	40	40	40
Type	--	Veg.	Rock	Rock	Rock
Percent Chance of Use	--	4	4	4	4
Average Curve No. - Cond. II	--	77	77	77	79
Emergency Spillway Hydrograph					
Storm Rainfall (6 hr.)	Inches	6.02	6.02	6.02	6.02
Storm Runoff	Inches	3.50	3.50	3.50	3.70
Velocity of Flow (Vc) 1/	Ft./Sec.	3.0	2.4	2.8	2.7
Discharge Rate 1/	c.f.s.	32	16	28	24
Maximum W. S. Elevation 1/	Feet	1,484.6	1,446.2	1,463.7	1,522.4
Freeboard Hydrograph					
Storm Rainfall (6 hr.)	Inches	8.62	8.62	8.62	8.62
Storm Runoff	Inches	5.84	5.84	5.84	6.09
Velocity of Flow (Vc) 1/	Ft./Sec.	7.0	6.6	7.1	7.2
Discharge Rate 1/	c.f.s.	436	368	460	464
Maximum W. S. Elevation 1/	Feet	1,486.9	1,448.6	1,466.2	1,525.0
Principal Spillway					
Capacity - Low Stage	c.f.s.	32.1	16.2	34.8	43.7
Capacity - High Stage	c.f.s.	2/	2/	2/	109.3
Capacity Equivalents					
Sediment Volume	Inches	0.55 4/	0.5	0.55 4/	0.55 4/
Detention Volume	Inches	3.25	3.25	3.25	3.45
Spillway Storage	Inches	2.15	2.00	2.35	4.15
Class of Structure	--	a	a	a	a

1/ Maximum during passage of hydrograph
2/ Single stage CMP principal spillway
3/ Emergency spillway hydrograph is contained below crest of emergency spillway
4/ 0.05" sediment is stored above the principal spillway

March 1963

TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES

Little Walnut-Hickory Watershed, Kansas

Sheet 6 of 11

ITEM	UNIT	STRUCTURE NUMBER 21	22	23	24
Drainage Area	Sq. Mi.	5.52	2.75	1.60	0.93
Storage Capacity					
Sediment	Ac. Ft.	162	81	43	25
Floodwater	Ac. Ft.	1,016	499	315	175
Total	Ac. Ft.	1,178	580	358	200
Between High and Low Stages	Ac. Ft.	751	2/	213	2/
Surface Area					
Sediment Pool	Acres	34	15	5	6
Floodwater Pool	Acres	136	56	37	29
Volume of Fill	Cu. Yds.	98,554	53,520	45,906	36,895
Elevation Top of Dam	Feet	1,533.2	1,358.2	1,387.8	1,392.3
Maximum Height of Dam	Feet	30.0	36.2	34.8	25.3
Emergency Spillway					
Crest Elevation	Feet	1,528.2	1,354.3	1,381.0	1,388.8
Bottom Width	Feet	40	40	40	40
Type	--	Rock	Rock	Rock	Rock
Percent Chance of Use	--	4	4	2	4
Average Curve No. - Cond. II	--	79	78	79	79
Emergency Spillway Hydrograph					
Storm Rainfall (6 hr.)	Inches	6.02	6.02	8.62	6.02
Storm Runoff	Inches	3.70	3.60	6.09	3.70
Velocity of Flow (Vc) 1/	Ft./Sec.	2.4	2.9	6.9	3/
Discharge Rate 1/	c.f.s.	16	32	416	3/
Maximum W. S. Elevation 1/	Feet	1,528.6	1,355.1	1,384.0	3/
Freeboard Hydrograph					
Storm Rainfall (6 hr.)	Inches	8.62	8.62	14.62	8.62
Storm Runoff	Inches	6.09	5.97	11.85	6.09
Velocity of Flow (Vc) 1/	Ft./Sec.	7.8	8.0	11.2	5.6
Discharge Rate 1/	c.f.s.	592	648	1,720	256
Maximum W. S. Elevation 1/	Feet	1,531.9	1,358.2	1,387.8	1,391.1
Principal Spillway					
Capacity - Low Stage	c.f.s.	55.2	35.2	16.0	14.0
Capacity - High Stage	c.f.s.	138.0	2/	37.5	2/
Capacity Equivalents					
Sediment Volume	Inches	0.55 4/	0.55 4/	0.50	0.50
Detention Volume	Inches	3.45	3.40	3.70	3.52
Spillway Storage	Inches	3.25	1.60	3.75	2.48
Class of Structure	--	a	a	b	a

1/ Maximum during passage of hydrograph
2/ Single stage CMP principal spillway
3/ Emergency spillway hydrograph is contained below crest of emergency spillway
4/ 0.05" sediment is stored above the principal spillway

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TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES

Little Walnut-Hickory Watershed, Kansas

Sheet 7 of 11

ITEM	UNIT	STRUCTURE NUMBER 25	26	27	28
Drainage Area	Sq. Mi.	0.51	2.29	0.65	3.26
Storage Capacity					
Sediment	Ac. Ft.	14	67	17	96
Floodwater	Ac. Ft.	96	430	122	600
Total	Ac. Ft.	110	497	139	696
Between High and Low Stages	Ac. Ft.	2/	2/	2/	444
Surface Area					
Sediment Pool	Acres	6	15	6	26
Floodwater Pool	Acres	15	56	24	92
Volume of Fill	Cu. Yds.	26,610	52,935	32,804	102,798
Elevation Top of Dam	Feet	1,446.2	1,407.7	1,489.5	1,485.0
Maximum Height of Dam	Feet	22.7	29.2	21.0	29.5
Emergency Spillway					
Crest Elevation	Feet	1,442.7	1,403.7	1,486.0	1,480.0
Bottom Width	Feet	40	40	40	40
Type	--	Rock	Rock	Rock	Rock
Percent Chance of Use	--	4	4	4	4
Average Curve No. - Cond. II	--	79	79	79	79
Emergency Spillway Hydrograph					
Storm Rainfall (6 hr.)	Inches	6.02	6.02	6.02	6.02
Storm Runoff	Inches	3.70	3.70	3.70	3.70
Velocity of Flow (Vc)1/	Ft./Sec.	3/	3/	3/	3.0
Discharge Rate1/	c.f.s.	3/	3/	3/	32
Maximum W. S. Elevation1/	Feet	3/	3/	3/	1,480.8
Freeboard Hydrograph					
Storm Rainfall (6 hr.)	Inches	8.62	8.62	8.62	8.62
Storm Runoff	Inches	6.09	6.09	6.09	6.09
Velocity of Flow (Vc)1/	Ft./Sec.	5.5	7.3	5.3	7.3
Discharge Rate1/	c.f.s.	204	488	180	488
Maximum W. S. Elevation1/	Feet	1,444.7	1,407.0	1,487.9	1,483.3
Principal Spillway					
Capacity - Low Stage	c.f.s.	7.7	34.2	9.8	32.6
Capacity - High Stage	c.f.s.	2/	2/	2/	80.8
Capacity Equivalents					
Sediment Volume	Inches	0.50	0.55 4/	0.50	0.55 4/
Detention Volume	Inches	3.52	3.52	3.52	3.45
Spillway Storage	Inches	2.20	2.18	3.05	3.50
Class of Structure	--	a	a	a	a

1/ Maximum during passage of hydrograph
2/ Single stage CMP principal spillway
3/ Emergency spillway hydrograph is contained below crest of emergency spillway
4/ 0.05" sediment is stored above the principal spillway

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TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES

Little Walnut-Hickory Watershed, Kansas

Sheet 8 of 11

ITEM	UNIT	STRUCTURE NUMBER 29	30	31	32
Drainage Area	Sq. Mi.	6.39	1.70	1.04	1.67
Storage Capacity					
Sediment	Ac. Ft.	187	45	28	44
Floodwater	Ac. Ft.	1,261	319	205	313
Total	Ac. Ft.	1,448	364	233	357
Between High and Low Stages	Ac. Ft.	869	2/	139	2/
Surface Area					
Sediment Pool	Acres	35	12	10	17
Floodwater Pool	Acres	135	40	43	54
Volume of Fill	Cu. Yds.	151,373	43,288	43,496	48,470
Elevation Top of Dam	Feet	1,401.0	1,474.5	1,568.7	1,516.1
Maximum Height of Dam	Feet	41.0	27.5	21.2	19.6
Emergency Spillway					
Crest Elevation	Feet	1,392.9	1,470.7	1,563.7	1,512.6
Bottom Width	Feet	100	40	40	40
Type	--	Rock	Rock	Rock	Rock
Percent Chance of Use	--	2	4	2	4
Average Curve No. - Cond. II	--	79	79	79	79
Emergency Spillway Hydrograph					
Storm Rainfall (6 hr.)	Inches	8.62	6.02	8.62	6.02
Storm Runoff	Inches	6.09	3.70	6.09	3.70
Velocity of Flow (Vc) 1/	Ft./Sec.	7.4	3/	5.4	3/
Discharge Rate 1/	c.f.s.	1,280	3/	196	3/
Maximum W. S. Elevation 1/	Feet	1,396.3	3/	1,565.7	3/
Freeboard Hydrograph					
Storm Rainfall (6 hr.)	Inches	14.6	8.62	14.6	8.62
Storm Runoff	Inches	11.83	6.09	11.83	6.09
Velocity of Flow (Vc) 1/	Ft./Sec.	12.1	7.2	8.9	6.5
Discharge Rate 1/	c.f.s.	5,600	464	880	344
Maximum W. S. Elevation 1/	Feet	1,401.0	1,473.9	1,568.3	1,515.3
Principal Spillway					
Capacity - Low Stage	c.f.s.	63.9	22.9	10.4	26.6
Capacity - High Stage	c.f.s.	159.8	2/	26.0	2/
Capacity Equivalents					
Sediment Volume	Inches	0.55 4/	0.50	0.50	0.50
Detention Volume	Inches	3.70	3.52	3.70	3.52
Spillway Storage	Inches	3.60	1.93	4.90	2.40
Class of Structure	--	b	a	b	a

1/ Maximum during passage of hydrograph
2/ Single stage CMP principal spillway
3/ Emergency spillway hydrograph is contained below crest of emergency spillway
4/ 0.05" sediment is stored above the principal spillway

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TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES

Little Walnut-Hickory Watershed, Kansas

Sheet 9 of 11

ITEM	UNIT	STRUCTURE NUMBER			
		33	34	35	36
Drainage Area	Sq. Mi.	0.79	1.39	1.58	1.31
Storage Capacity					
Sediment	Ac. Ft.	21	37	42	35
Floodwater	Ac. Ft.	149	261	312	251
Total	Ac. Ft.	170	298	354	286
Between High and Low Stages	Ac. Ft.	2/	2/	211	167
Surface Area					
Sediment Pool	Acres	7	14	14	11
Floodwater Pool	Acres	31	45	54	34
Volume of Fill	Cu. Yds.	39,925	61,424	52,263	52,042
Elevation Top of Dam	Feet	1,527.2	1,571.1	1,474.3	1,454.1
Maximum Height of Dam	Feet	19.2	20.1	25.0	26.6
Emergency Spillway					
Crest Elevation	Feet	1,523.7	1,567.6	1,469.2	1,448.4
Bottom Width	Feet	40	40	60	50
Type	--	Rock	Veg.	Veg.	Rock
Percent Chance of Use	--	4	4	2	2
Average Curve No. - Cond. II	--	79	79	79	78
Emergency Spillway Hydrograph					
Storm Rainfall (6 hr.)	Inches	6.02	6.02	8.62	8.62
Storm Runoff	Inches	3.70	3.70	6.09	5.97
Velocity of Flow (Vc)1/	Ft./Sec.	3/	3/	5.7	6.2
Discharge Rate1/	c.f.s.	3/	3/	348	375
Maximum W. S. Elevation1/	Feet	3/	3/	1,471.4	1,450.9
Freeboard Hydrograph					
Storm Rainfall (6 hr.)	Inches	8.62	8.62	14.6	14.6
Storm Runoff	Inches	6.09	6.09	11.83	11.7
Velocity of Flow (Vc)1/	Ft./Sec.	5.2	6.4	9.4	10.0
Discharge Rate1/	c.f.s.	180	320	1,584	1,605
Maximum W. S. Elevation1/	Feet	1,525.6	1,570.2	1,474.3	1,454.1
Principal Spillway					
Capacity - Low Stage	c.f.s.	11.9	20.2	15.8	13.1
Capacity - High Stage	c.f.s.	2/	2/	39.5	32.8
Capacity Equivalents					
Sediment Volume	Inches	0.50	0.50	0.50	0.50
Detention Volume	Inches	3.52	3.52	3.70	3.60
Spillway Storage	Inches	3.68	2.43	3.90	3.28
Class of Structure	--	a	a	b	b

1/ Maximum during passage of hydrograph
2/ Single stage CMP principal spillway
3/ Emergency spillway hydrograph is contained below crest of emergency spillway
4/ 0.05" sediment is stored above the principal spillway

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TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES

Little Walnut-Hickory Watershed, Kansas

Sheet 10 of 11

ITEM	UNIT	STRUCTURE NUMBER 37	38	39	40
Drainage Area	Sq. Mi.	3.43	1.14	3.65	0.88
Storage Capacity					
Sediment	Ac. Ft.	101	30	107	24
Floodwater	Ac. Ft.	613	207	652	160
Total	Ac. Ft.	714	237	759	184
Between High and Low Stages	Ac. Ft.	448	2/	477	2/
Surface Area					
Sediment Pool	Acres	21	9	24	6
Floodwater Pool	Acres	86	33	91	24
Volume of Fill	Cu. Yds.	91,204	46,153	62,714	40,205
Elevation Top of Dam	Feet	1,496.9	1,487.2	1,519.1	1,499.7
Maximum Height of Dam	Feet	30.4	28.1	30.6	27.2
Emergency Spillway					
Crest Elevation	Feet	1,491.9	1,483.6	1,514.1	1,496.2
Bottom Width	Feet	40	40	40	40
Type	--	Veg.	Rock	Rock	Rock
Percent Chance of Use	--	4	4	4	4
Average Curve No. - Cond. II	--	78	78	78	78
Emergency Spillway Hydrograph					
Storm Rainfall (6 hr.)	Inches	6.02	6.02	6.02	6.02
Storm Runoff	Inches	3.61	3.61	3.61	3.61
Velocity of Flow (Vc) 1/	Ft./Sec.	2.8	2.7	2.9	3/
Discharge Rate 1/	c.f.s.	28	24	32	3/
Maximum W. S. Elevation 1/	Feet	1,492.6	1,484.2	1,514.9	3/
Freeboard Hydrograph					
Storm Rainfall (6 hr.)	Inches	8.62	8.62	8.62	8.62
Storm Runoff	Inches	5.97	5.97	5.97	5.97
Velocity of Flow (Vc) 1/	Ft./Sec.	7.6	6.4	7.6	6.0
Discharge Rate 1/	c.f.s.	540	320	540	276
Maximum W. S. Elevation 1/	Feet	1,495.4	1,486.2	1,517.6	1,498.6
Principal Spillway					
Capacity - Low Stage	c.f.s.	34.3	16.1	36.5	13.2
Capacity - High Stage	c.f.s.	85.8	2/	81.9	2/
Capacity Equivalents					
Sediment Volume	Inches	0.55 4/	0.50	0.55 4/	0.50
Detention Volume	Inches	3.35	3.40	3.35	3.40
Spillway Storage	Inches	3.10	2.20	3.00	2.10
Class of Structure	--	a	a	a	a

1/ Maximum during passage of hydrograph
2/ Single stage CMP principal spillway
3/ Emergency spillway hydrograph is contained below crest of emergency spillway
4/ 0.05" sediment is stored above the principal spillway

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TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES

Little Walnut-Hickory Watershed, Kansas

Sheet 11 of 11

ITEM	UNIT	TOTAL
Drainage Area	Sq. Mi.	92.23
Storage Capacity		
Sediment	Ac. Ft.	2,647
Floodwater	Ac. Ft.	17,075
Total	Ac. Ft.	19,722
Between High and Low Stages	Ac. Ft.	8,681
Surface Area		
Sediment Pool	Acres	660
Floodwater Pool	Acres	2,457
Volume of Fill	Cu. Yds.	2,378,627
Elevation Top of Dam	Feet	xxxxx
Maximum Height of Dam	Feet	xxxxx
Emergency Spillway		
Crest Elevation	Feet	xxxxx
Bottom Width	Feet	xxxxx
Type	--	xxxxx
Percent Chance of Use	--	xxxxx
Average Curve No. - Cond. II	--	xxxxx
Emergency Spillway Hydrograph		
Storm Rainfall (6 hr.)	Inches	xxxxx
Storm Runoff	Inches	xxxxx
Velocity of Flow (Vc) 1/	Ft./Sec.	xxxxx
Discharge Rate 1/	c.f.s.	xxxxx
Maximum W. S. Elevation 1/	Feet	xxxxx
Freeboard Hydrograph		
Storm Rainfall (6 hr.)	Inches	xxxxx
Storm Runoff	Inches	xxxxx
Velocity of Flow (Vc) 1/	Ft./Sec.	xxxxx
Discharge Rate 1/	c.f.s.	xxxxx
Maximum W. S. Elevation 1/	Feet	xxxxx
Principal Spillway		
Capacity - Low Stage	c.f.s.	xxxxx
Capacity - High Stage	c.f.s.	xxxxx
Capacity Equivalents		
Sediment Volume	Inches	xxxxx
Detention Volume	Inches	xxxxx
Spillway Storage	Inches	xxxxx
Class of Structure	--	xxxxx

1/ Maximum during passage of hydrograph
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TABLE 4 - ANNUAL COST

Little Walnut-Hickory Watershed, Kansas

(Dollars)

Evaluation Unit	Amortization of Installation Cost 1/	Operation and Maintenance Cost 2/	Total
Floodwater Retarding Structures	84,500	5,500	90,000
Total	84,500	5,500	90,000

1/ Amortized at 2 7/8 percent interest for a period of 50 years, base price 1962

2/ Computed at .36 percent of construction cost estimate, long term base price

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TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD REDUCTION BENEFITS

Little Walnut-Hickory Watershed, Kansas

(Dollars) 1/

Item	Estimated Average Annual Damage		Damage Reduction Benefits
	Without Project	With Project	
Floodwater			
Crop	191,400	92,600	98,800
Other Agricultural	23,200	8,400	14,800
Road and Bridge	24,200	8,500	15,700
Subtotal	238,800	109,500	129,300
Erosion			
Floodplain Scour 2/	26,900	16,800	10,100
Indirect	25,100	11,400	13,700
Total	290,800	137,700	153,100
Benefits from Outside the Watershed	xxxxx	xxxxx	15,400
GRAND TOTAL	xxxxx	xxxxx	168,500

1/ Price base - Long term projected

2/ Without project and with project includes $4,200 non-recoverable scour damage.

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Little Walnut-Hickory Watershed, Kansas

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/				Average Annual Cost 2/	Benefit Cost Ratio
	Flood Prevention			Total		
	Damage Reduction	More Intensive Land Use	Changed Land Use			
Floodwater Retarding Structures	163,300 3/	13,000	15,800	192,100	90,000	2.1:1

1/ Price base - Long term projected
2/ Price base - 1962 for amortization; long term price for operation and maintenance
3/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefit of $5,200 annually.

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INVESTIGATION AND ANALYSIS

COOPERATION IN PLANNING

General

The engineering, hydrology, geology, and economic investigations and analysis on this watershed were accomplished by Soil Conservation Service personnel except for structure site surveys. Structure site surveys were accomplished under contract with Wilson and Company, Engineers and Architects, Salina, Kansas.

Forestry

A Forestry Work Plan was developed by the District Extension Forester, Kansas State University, Manhattan, Kansas. The contents of the Forestry plan have been included in the over-all plan.

Bureau of Sport Fisheries and Wildlife

The Bureau of Sport Fisheries and Wildlife, in cooperation with the Kansas Forestry, Fish and Game Commission, made a reconnaissance study of the proposed Little Walnut-Hickory Watershed Project. The recommendations included in the report have been reviewed with the local sponsors and generally will be followed in installing and operating the project.

ENGINEERING

Surveys

Vertical control lines were run throughout the watershed with permanent bench marks established within 1/2 mile of each structure site and each valley cross section. One hundred and seventy-seven permanent bench marks were set in the watershed. All surveys were referenced to mean sea level.

Two hundred and three valley cross sections were field surveyed. Sufficient readings were made to define the topography along each section; to locate all crop boundaries and changes in roughness factor; to locate all roads, fences, and other objects along the sections; and to define the shape of the channel in detail.

Topographic maps of four structure sites were field surveyed and 36 were made by use of a kelsh plotter. The maps made by the kelsh plotter were developed from aerial photographs with a scale of 1 inch equals 800 feet. A maximum contour interval of 4 feet was used. Storage capacities were measured from the topography maps and stage-storage curves developed. Embankment quantities were calculated from centerline profiles which were surveyed on 36 sites by use of a kelsh plotter and

field surveyed on 4 sites. The acceptable accuracy of the kelsh work was verified by checking approximately 14 percent of the centerline profiles by field surveying.

Structure Design and Cost Estimates

Nineteen floodwater retarding structures are planned with two stage principal spillways and 21 with single stage principal spillways. These provided an economical design for the design storm and kept the outflow at desirable levels. The crest of the first stage, in the two stage spillways and of the single stage inlet, was planned at the elevation that provided the necessary sediment storage capacity in the reservoir. The second stage inlet was planned at the elevation that provided a 5-year detention storage. The crest of the emergency spillway was planned to provide a minimum 25-year detention storage above the principal spillway invert. The freeboard hydrograph was routed through all structures with the maximum elevation equal to or less than the elevation of the top of the dam. A minimum emergency spillway size of five feet deep by forty feet wide was used.

Structural data for each site is shown in Table 3.

A cost estimate was calculated for each structure. Quantities of each item were based on surveyed data. Unit costs reflecting current bid prices for embankment, principal spillways, riprap, fencing, drain pipes, seeding, clearing, etc. were used to arrive at the total construction cost of each structure. Contingencies were calculated at 12 percent of the engineers estimate. Installation services costs were calculated as a percent of construction costs.

Easements and rights-of-way costs were calculated for each site using unit values for cropland and pastureland agreed on by the sponsors.

Individual structure costs data is tabulated in Table 2 and the total cost of all proposed structures is shown in Table 1.

HYDROLOGY AND HYDRAULICS

The watershed was divided into 21 sub-watershed areas. Evaluation reaches were selected to coincide with the sub-watershed area limits. For location see project map.

Hydrologic soil-cover complex numbers were developed for each sub-watershed area for present and future watershed conditions. Future watershed conditions exist when the land treatment and cover measures outlined in this plan are in effect.

Rainfall frequency was obtained from United States Weather Bureau Technical Paper Number 25 and station data from Wichita, Kansas, which is about 20 miles west of the watershed.

To obtain the relation of rainfall to runoff, the procedure as outlined in Chapter 3.10 National Engineering Handbook, Section 4, Hydrology, Supplement A, was followed. A factor of 2.0 was used for conversion of annual flood plotting positions to partial duration plotting positions. The frequency versus volume runoff relationship was developed for the needed range of hydrologic soil-cover complex numbers.

The relationship between discharge and inundation was based on 203 field surveyed valley and channel cross sections. These cross sections were all related vertically to mean sea level datum. They were horizontally related by being located on aerial photograph maps, scale 3.2 inches equals 1 mile, and pantographed to a plan profile sheet at 1 inch equals 1,000 feet. The width flooded at the cross section and the distance between cross sections determined area flooded.

The IBM 650 electronic computer was used to make calculations for the hydraulics of the floodplain. A range of discharges were considered from below non-damage flow to above the 100-year frequency. The output from the computer gave elevation and area of inundation by depth increments for every discharge computed at each cross section.

The relationship of discharge to area of inundation by depth increments was developed for each reach by combining data for all cross sections within each reach.

The relation of unit volume runoff to discharge was developed by floodrouting using Wilson's method. Triangular hydrographs, representing the unit volume of runoff from each sub-watershed area, were used. Floodrouting determined the discharge for a unit volume of runoff for each evaluation reach. This determination was made for present conditions, future land treatment conditions, future land treatment conditions with various percentages of each sub-watershed controlled by floodwater retarding structures, and future land treatment conditions with the formulated structural system. This gave the discharge-volume runoff relations for each evaluation reach considering a 0 to 90 percent range of area controlled by reservoirs.

Frequency discharge and frequency area flooded relationships were tabulated for each of the above conditions.

A determination was made of the frequency of two historical storms which occurred in the watershed in 1951 and 1959. This was accomplished by securing high water marks for these storms and plotting them on the water surface profiles. This made it possible to determine the discharge of the actual storm at each reach. The discharge-frequency curve and the above discharges determined the frequency of the two storms at each reach.

Floodwater retarding structure release rates were established considering downstream channel capacities and economics of floodwater storage. Two stage release rates are planned in all structures having

over 500 acre feet of detention storage and single stage releases in all structures with less than 500 acre feet of detention storage. Combined maximum release rates will not exceed channel capacity. Individual structure release rates are shown in Table 3.

The floodwater detention storage volume was determined by procedures in SCS Technical Release Number 10. Storms used in connection with this procedure were taken from Weather Bureau Technical Paper No. 40. In structures having two stage principal spillways, the volume for flood storage up to the second stage was computed using 5-year frequency storms. The total volume for floodwater storage in all structures was computed using 25-year frequency storms.

Dimensions of the emergency spillways were determined by floodrouting the storms indicated in SCS Engineering Memorandum No. 27 by the method outlined in Lincoln E&WPU Memorandum No. 2. Emergency spillways will exceed minimum criteria as established by the State of Kansas.

GEOLOGIC INVESTIGATIONS

Sedimentation in Reservoirs

Sediment rates and volumes were determined from sedimentation surveys made on existing reservoirs in the area. The range survey method was used to determine the sediment volume accumulated in each reservoir. Equipment used included survey instruments, boat, cable and meter, spud bar, and sounding bell.

Delta deposits were measured at from five to ten percent of the total sediment volume.

The significant sediment production factors of soil type, slope of the land, land use, and type of erosion were mapped on the drainage area above each surveyed reservoir. Sediment rates were computed for each reservoir. Variations in the sediment rates were equated to the difference in the sediment producing factors of the drainage area.

Sediment rating curves were developed from the above computations. These curves show sediment yield in acre feet per square mile per year versus drainage area size. These curves were plotted for a range of sediment producing factors.

Sediment producing factors of the drainage areas above floodwater retarding structures were mapped and compiled. Sediment yield to each reservoir was read from the sediment rating curves. An additional 10 percent was added above the sediment pool for delta deposition on reservoirs having a drainage area in excess of two square miles.

Floodplain Scour

The extent and severity of sheet scour and channel scour resulting from floods on the floodplain was determined. The scour areas were mapped in the field on aerial photographs. The degree of damage was

based on the loss of productivity as compared with the unaffected parts of the field. Information derived from interviews with work unit personnel, soil scientists, and farmers aided in assembling land damage information.

Sheet and channel erosion was tabulated in acres with the percent of damage by elevation reaches. Only eroded areas affected by upstream runoff were considered.

Future scour erosion in the next 50 years was estimated without the program for each reach. Future damage was based on soil type, present soil depth on the eroded areas, and the annual rate of erosion. The future damages were computed by:

Present percent of damage divided by years of accelerated erosion times 50 years plus present percent of erosion is equal to percent of damage in 50 years (not to exceed 100 percent).

The recovery period for each reach in years was established from the amount of damage, the soil type, and the length and number of crop rotations required for potential recovery.

The potential recovery of soil productivity without floods depends primarily on the capability class of the soil and the present soil depth. Affected areas having soil with 60 inches or more in depth and in Class I and II are considered capable of full recovery. Other classes of land with less depth of soil were considered to recover partially as compared to original productiveness.

The percent of recovery for each evaluation reach at the end of the recovery period was determined by:

Present damage times percent of potential recovery times percent of area control is equal to percent of recovery.

Damsites

A geologic investigation was conducted at each proposed dam site. The work was accomplished by field observation, use of existing geologic maps, surveying instruments and hand and power augers. The report on each dam site includes a centerline profile showing geologic conditions, the borrow area shown on the topographic map and a summary sheet.

Significant geologic features that might influence the design or construction of a structure were investigated. A limited number of test holes on the centerline determined the stability of the foundation. The amount of stripping and the depth of core trench were noted from the logs of the testholes.

The recommended location of the principal spillway was determined from the density of the foundation, amount of excavation, length of

conduit and the alignment of the pipe outlet to the stream channel. Materials to be excavated from the emergency spillway were estimated in quantities and their potential uses during construction were determined.

All soils investigated were classified by the Unified Soil Classification.

ECONOMIC INVESTIGATIONS

The Frequency Method as described in Chapter 3 of the Economics Guide was followed in determining the average annual floodwater damages.

The watershed was divided into twenty-one sub-watersheds with evaluation reaches set to coincide with the sub-watersheds.

Basic data necessary for the determination of present damages were collected by personal contacts with farm operators, township and county officials, oil field representatives, and with local agricultural technicians. Remaining damages were computed by types in each of the evaluation reaches based on future conditions of land treatment with 30, 50, 70, and 90 percent of the drainage area controlled by reservoirs and with formulated works of improvement in place. Benefits were computed for more intensive use and changed land use under these same conditions.

Floodwater damage to crops reflects the net loss in income for the 100-year storm series. It was computed by the determination of acres of cropland flooded and their depths of inundation. A composite acre of floodplain use was determined by interviews with farm operators and checked by field reconnaissance.

Average crop yields for the area, adjusted to flood-free conditions by judgment of farm operators and agricultural technicians familiar with the area, were used in the evaluation. A different composite acre and average yields were developed in a similar manner for use in determining the benefits attributable to more intensive use and changed land use. The composite acre of crops on the floodplain and their flood-free yields are as follows:

Crops	Present Use Percent Use	Flood-free Yield
Alfalfa	20	4 Ton
Corn	20	65 Bu.
Milo	20	70 Bu.
Wheat	15	35 Bu.
Timber	10	--
Forage Sorghums	5	15 Ton
Soybeans	5	25 Bu.
Tame Grasses	5	10 A.U.M.

Crops	More Intensive Use Percent Use	Flood-Free Yield
Alfalfa	20	4.5 Ton
Corn	20	70 Bu.
Milo	20	75 Bu.
Wheat	15	40 Bu.
Timber	10	--
Forage Sorghums	5	17 Bu.
Soybeans	5	30 Bu.
Tame Grasses	5	10 A.U.M.

The net value of the composite acre was weighted using lower values in the scoured areas. The damageable values by depth increments were adjusted to reflect the weighted values.

A percent loss from each crop was developed considering depth of inundation and month of flooding. The percent damage was used to determine damage for the composite acre. The rates of damage thus developed were weighted by the percent of the year's excessive storms that occur in each month and the weighted rate multiplied by acreages inundated by selected discharges. A dollar damage versus discharge curve was developed to provide a monetary value for each storm discharge in the 100-year storm series.

Damage schedules were obtained from 50 to 85 percent of the landowners and operators of the floodplain area in each evaluation reach and the values expanded to 100 percent. The specific storms covered were July, 1951, and a minor storm in July, 1959. From rainfall records and high water marks, the frequency of these storms were determined for each evaluation reach. The damage schedules covered other agricultural damages such as losses of livestock, machinery, and stored grains; removal of debris; and damage to private roads, channel crossings, and fences.

Road and bridge damages were based on information obtained from the county engineers office as to their repair or replacement costs. Road damages were computed as the dollar damage per foot by depth increments of inundation for the various types of road surfaces within the watershed. Bridge damages were estimated on individual bridges by various discharges. Road and bridge damages were then combined in each evaluation reach and dollar damage versus discharge curves were plotted. These curves were then applied to the 100-year storm series.

Indirect damages such as depreciation of property in the flooded areas, loss of time and additional expense of operators used in repair and clean-up which would normally be used in a productive operation, and additional distances driven by rural mail carriers, school busses, and farmers because of flooded roads, were considered. The indirect damages were computed as 10 percent of the crop and other agricultural damages and 15 percent of road and bridge damage.

The estimate of damages to land through floodplain scour was derived from data gathered in the field by the geologist regarding acres damaged, severity of damage, and period and degree of recovery due to the installed program. The economic evaluation was based on the net value of the composite acre. The changes in net income due to scour damage was discounted at a 4 percent interest rate.

The off-project damage area considered is the Walnut River floodplain from its junction with the Arkansas River upstream to the junction with the Little Walnut River. Present damages were determined for the city of Winfield from data compiled by the Corps of Engineers. Crop damage estimate was based on the damage per acre as determined in the lower reach of the Little Walnut-Hickory Watershed evaluation and applied to the floodplain acres which was obtained from the Corps of Engineers.

The off-project benefits assigned to Little Walnut-Hickory project are its fair share of the benefits accruing to the 31,450 acres of affected Walnut River floodplain. The Little Walnut-Hickory share of the benefits was obtained by determining the percent reduction in peak discharge attributed to the Little Walnut-Hickory control.

The procedures used in determining the reductions in peak discharge are described in Part II of Engineering Report, Little Walnut-Hickory Watershed, Preliminary Planning Investigation, September 1960, Servis, Van Doren, and Hazard, Engineers, Topeka, Kansas.

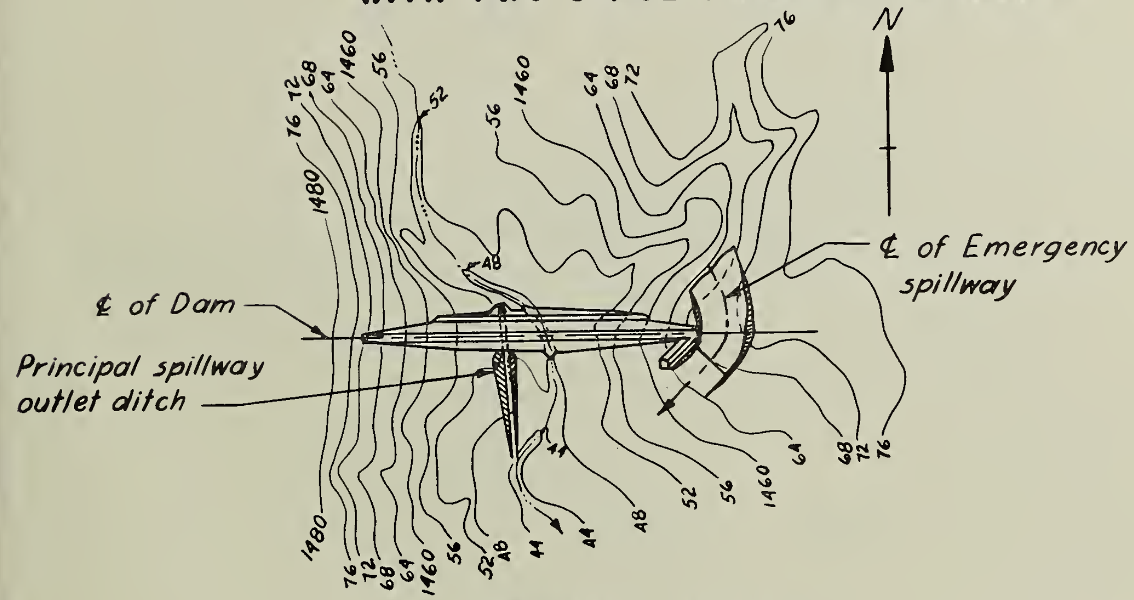
It was estimated that 486 acres of pastureland interspersed with brush and trees in localized areas adjacent to the stream banks will be cleared and used for crop production. This determination was supported by interviews with farmers, measurements of aerial photos, and from past experiences within the pilot watersheds. The farm owners and operators reported that where the topography allows, and where the expected frequency of damaging floods can be substantially reduced, that this change of land use will occur.

The cost of easements and rights-of-way were based on the value of cropland and pasture as determined by the Little Walnut-Hickory Watershed Directors. These values, slightly higher than the capitalized value of net production, were used for project evaluation. The values agreed on were $100 per acre for upland and second bottom cropland, $125 for first bottomcropland and $75 per acre for pasture for the floodwater detention sites. Land costs of the sediment pool areas were based on 100 percent of its value, the structure and spillway areas on 75 percent, and the detention areas on 50 percent. The productive capacity retained under future conditions were thereby considered.

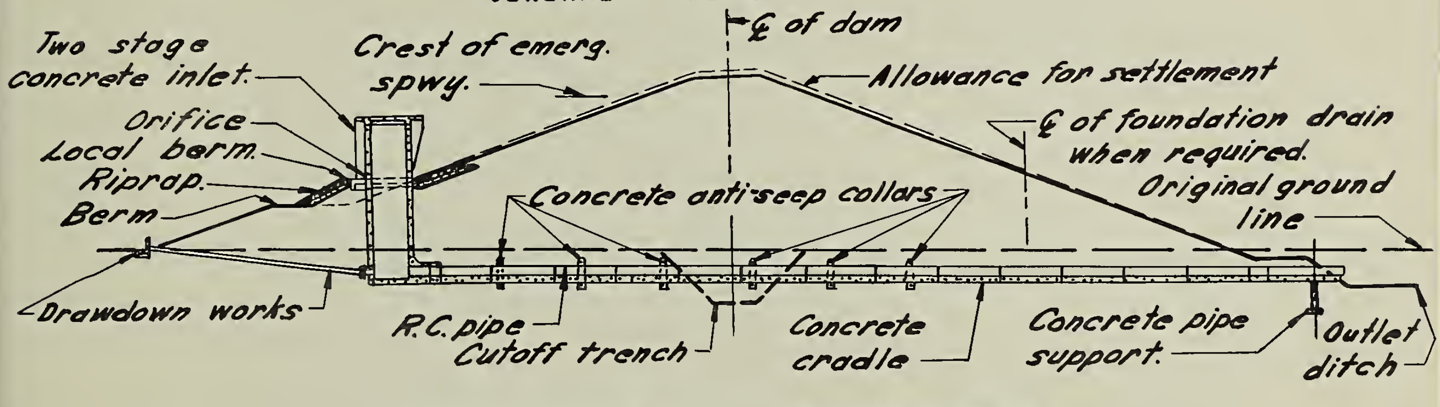
All monetary evaluations for benefits were based on long-term projected prices using "Agricultural Price and Cost Projections," Agricultural Research Service, dated September, 1957. Nineteen-sixty two construction costs as experienced in Kansas P.L. 566 projects under

construction were used to estimate the construction costs of structural measures. Operation and maintenance costs were computed at .36 percent of construction cost for floodwater retarding structures. This factor also reflects long term projected price levels. This method of computing O and M costs (outlined by the Lincoln, Nebraska, Engineering and Watershed Planning Unit) is based on the principle that the relative probability of need for major type repairs decreases as the number of structures increases. Federal and local costs were amortized at 2-7/8 percent interest rate for a period of fifty years.

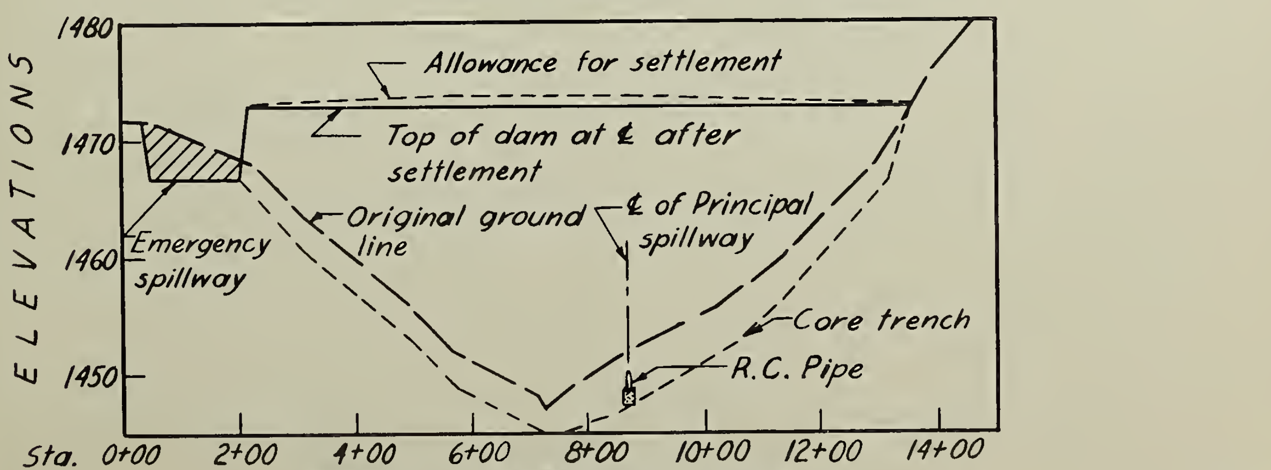
TYPICAL FLOODWATER RETARDING STRUCTURE WITH TWO STAGE PRINCIPAL SPILLWAY



GENERAL PLAN



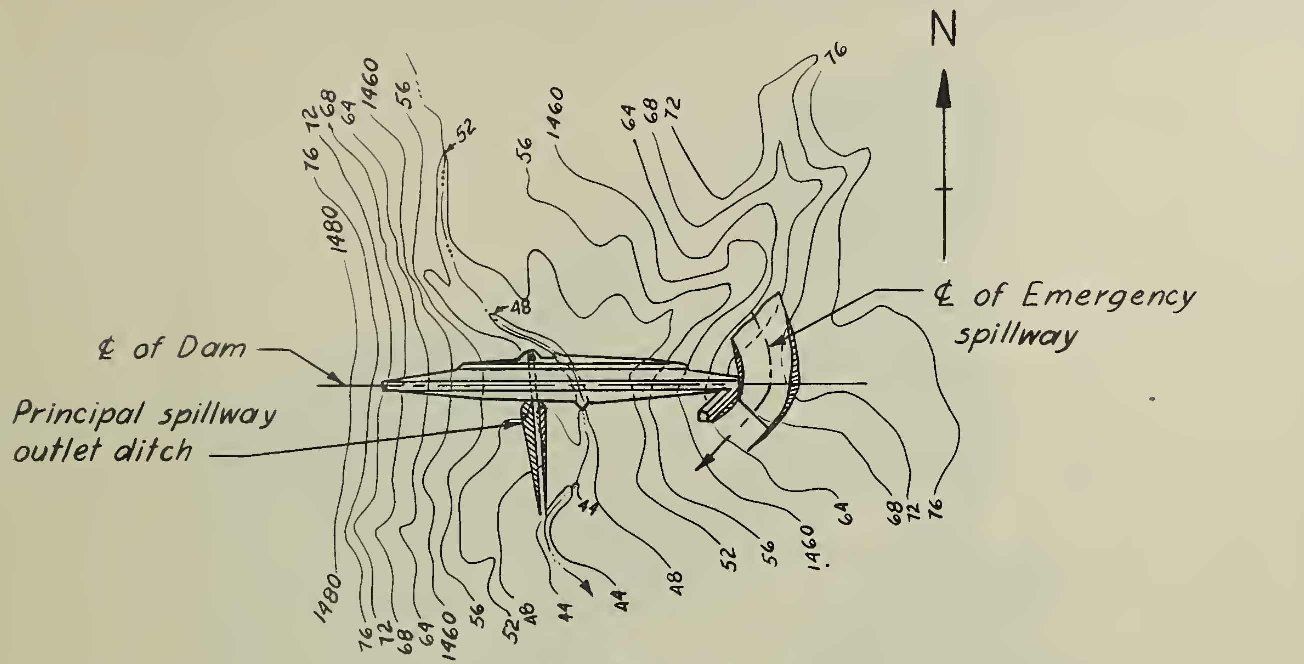
CROSS SECTION OF DAM ON CENTERLINE OF TWO STAGE PRINCIPAL SPILLWAY



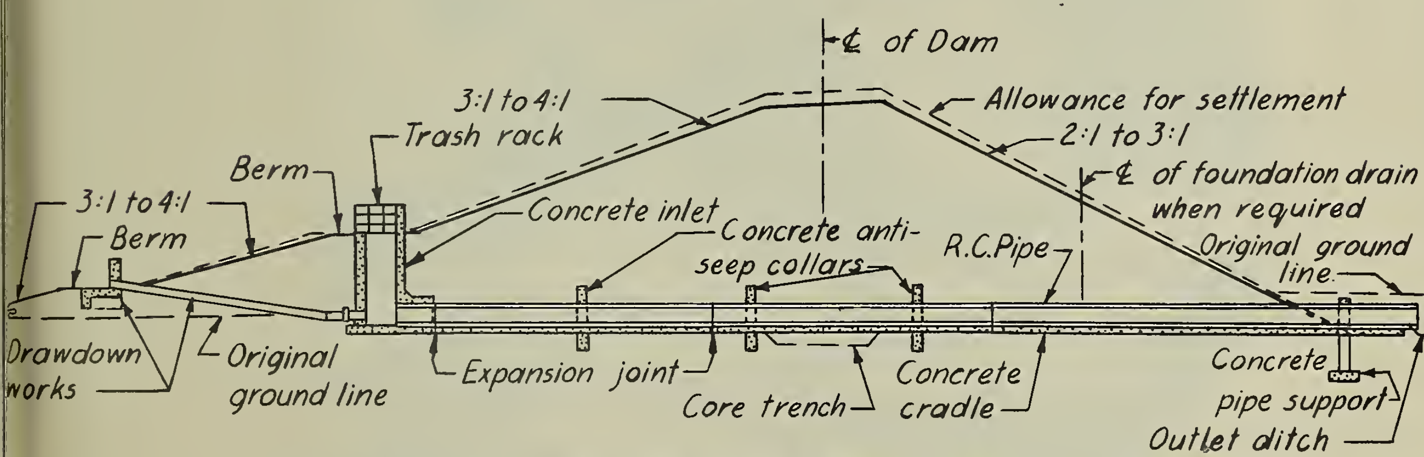
PROFILE ON CENTERLINE OF DAM

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

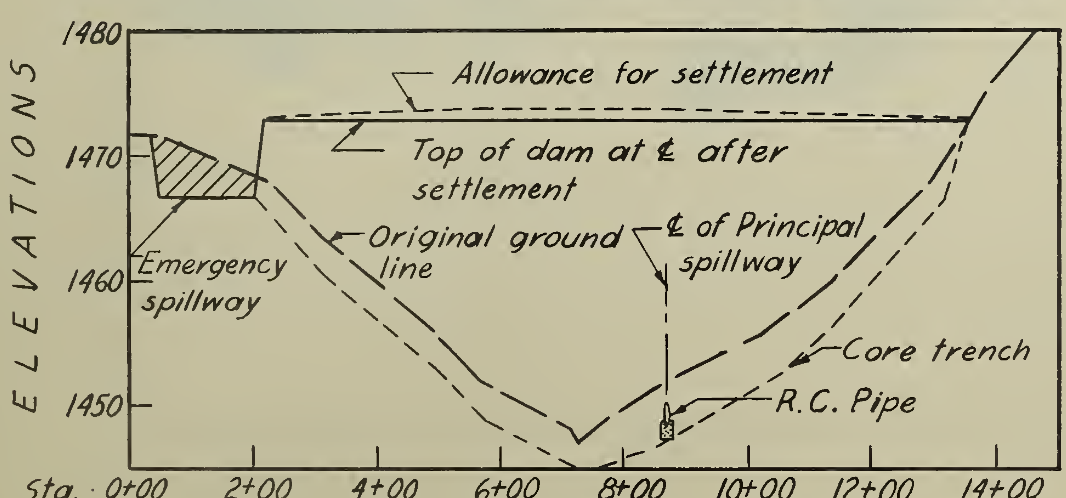
TYPICAL FLOODWATER RETARDING STRUCTURE



GENERAL PLAN



CROSS SECTION OF DAM ON CENTERLINE OF PRINCIPAL SPILLWAY



PROFILE ON CENTERLINE OF DAM

Rev. 4-60 5,L-15,520

SOIL CONSERVATION SERVICE

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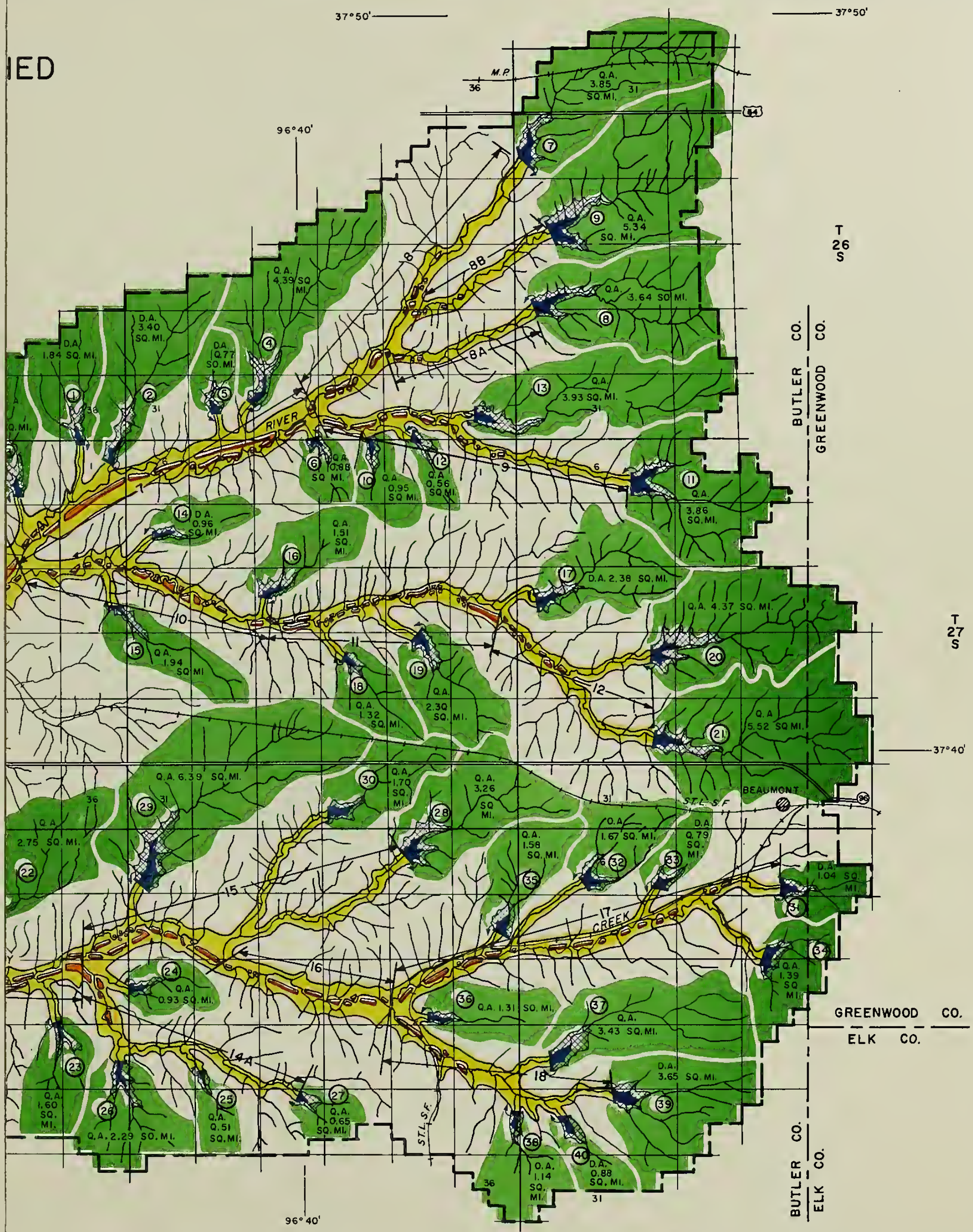
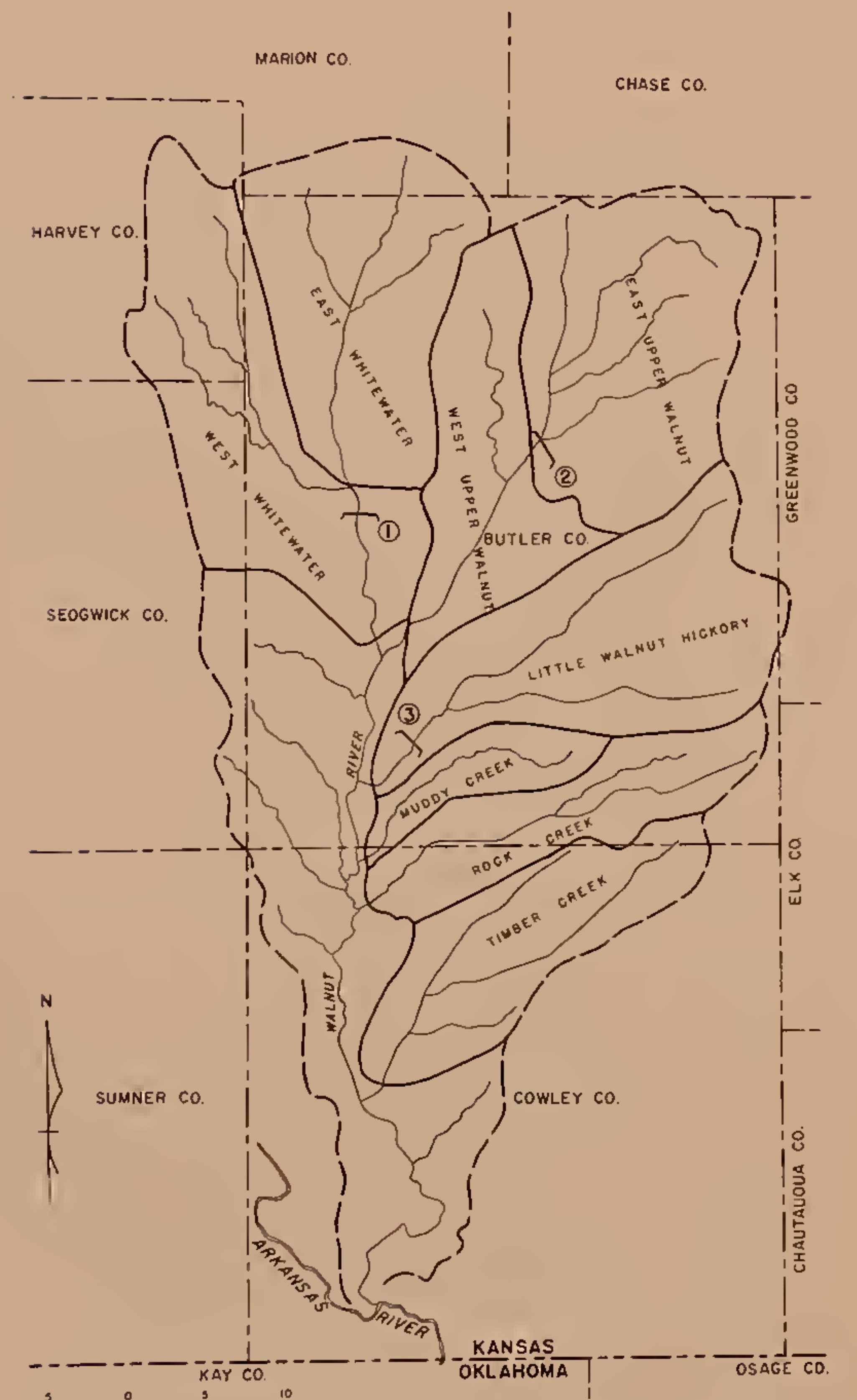


MILES

5,S-18,849

WATERSHED PROJECTS LOCATION
WALNUT RIVER BASIN



KEY

DAM SITES UNDER STUDY BY CORPS OF ENGINEERS

① TOWANDA RESERVOIR
② EL DORADO RESERVOIR
③ DOUGLASS RESERVOIR

LEGEND

WALNUT RIVER WATERSHED BOUNDARY

PROJECT WATERSHED BOUNDARY